

## Original Article

# Evaluating optimal stocking density for the tank polyculture system of whiteleg shrimp (*Litopenaeus vannamei*) and all-male giant freshwater prawn (*Macrobrachium rosenbergii*) postlarvae

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**Abstract:** Whiteleg shrimp (*Litopenaeus vannamei*) and giant freshwater prawns (*Macrobrachium rosenbergii*) are significant crustaceans in aquaculture, and they are compatible for bi-farming systems. This study assessed the best stocking density for a tank-based polyculture system comprising postlarval whiteleg shrimp and all-male giant freshwater prawns. The study used a completely randomized design with three replications. Whiteleg shrimp were stocked at four densities (5, 10, 15, and 20 individuals/m<sup>3</sup>—ind m<sup>-3</sup>), whereas all-male giant freshwater prawns were maintained at 5 ind m<sup>-3</sup> in 4 m<sup>3</sup> tanks with partial shading. After two months of rearing using a commercial pellet feed (42% crude protein), survival rates, as well as weight and length growth performance parameters (final mean weight, daily weight gain, specific growth rate in weight, final mean length, daily length gain, and specific growth rate in length) of both trial animals, were significantly higher at shrimp stocking densities of 5 and 10 ind m<sup>-3</sup> than 15 and 20 ind m<sup>-3</sup> ( $P \leq 0.05$ ). There were no significant changes in survival rates or growth performance parameters between densities of 5 and 10 ind m<sup>-3</sup> ( $P \geq 0.05$ ). Productivity was significantly lower at 5 ind m<sup>-3</sup> compared to other densities ( $P \leq 0.05$ ), while there were no significant differences among higher stocking densities (10-20 ind m<sup>-3</sup>) ( $P \geq 0.05$ ). The findings indicate that a stocking density of 10 ind m<sup>-3</sup> for whiteleg shrimp and 5 ind m<sup>-3</sup> for all-male giant freshwater prawn offers the optimal balance of growth, survival, and productivity in the experimental system.

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## Introduction

Over the last decades, aquaculture has emerged as a highly productive sector of global food production, propelled by technological advancements, improved management practices, efficient resource utilization, and an emphasis on sustainability (FAO, 2018). Among the key factors influencing aquaculture performance, stocking density plays a critical role, as growth rates of farmed species remain density-dependent even under optimal environmental conditions (Silveira et al., 2022). Overstocking densities can compromise water quality and increase disease risk and operational costs, including feed and seed expenses (Shoko et al., 2016; Oké and Goosen, 2019), whereas understocking leads to inefficient

resource utilization and lower yields (Krummenauer et al., 2011; Silveira et al., 2022).

To enhance shrimp farming productivity, multi-phase grow-out systems, in which shrimp are transferred from the nursery to the grow-out phase, are of increasing interest (Van Wyk, 1999). These systems align biomass more effectively with carrying capacity, leading to better survival, feed efficiency, and disease control than single-phase systems, which often underutilize capacity until harvest (Stern and Letellier, 1992; Van Wyk, 1999; Wang and Leiman, 2000). Moreover, feed remains the primary source of nutrient loading in shrimp culture, with only about 22% of nitrogen converted into shrimp biomass; the remainder accumulates in sediments or enters

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surrounding waters (Jackson et al., 2003). Thus, integrated multitrophic aquaculture (IMTA) and polyculture systems have been promoted as more sustainable alternatives to monoculture because compatible animals in polyculture systems occupy distinct ecological niches and have complementary feeding habits, enhancing nutrient recycling, boosting productivity, and improving system resilience (Dong et al., 2018; Lalramchhani et al., 2019; Erwiantono et al., 2020; N'souvi et al., 2021).

Among aquaculture crustaceans, *L. vannamei* accounts for the majority of global shrimp production due to its rapid growth, disease resistance, and tolerance of a wide range of salinities (FAO, 2017, 2020). This dominance is further supported by hatchery innovations and the adoption of specific pathogen-free (SPF) broodstock (Lightner, 2011; Kumar et al., 2023; Wani et al., 2024). However, the intensive monoculture of *L. vannamei* has been associated with water quality deterioration and heightened disease risk (Paulraj et al., 2016; Kumar et al., 2017). Whiteleg shrimp is particularly well-suited for co-culture with various fish and crustacean species across different production systems. Examples include polyculture with razor clam (*Sinonovacula constricta*) in ponds (Zhao et al., 2025), grey mullet (*Mugil cephalus*) and red tilapia (*Oreochromis spp.*) in closed biofloc-based systems (Nguyen et al., 2023), and swimming crab (*Portunus trituberculatus*) in enclosure systems housed in a pond (Zhou et al., 2022). Meanwhile, *Macrobrachium rosenbergii*, the largest species in its genus, is a valuable aquaculture species owing to its nutritional and commercial value (Maliwat et al., 2021; Sumi et al., 2025). Although it is a freshwater species, its larvae need brackish water to grow (Civin-Aralar et al., 2011; López-Uriostegui et al., 2014). These benthic feeders do not need a lot of protein (Prianka et al., 2016), and they mainly eat benthic organisms and organic matter that has fallen to the bottom of the pond (Rahman et al., 2012; Prianka et al., 2016). It has been reported that all-male populations of *M. rosenbergii* are more productive than mixed populations (Levy et al., 2017). This all-male prawn population has also been successfully

polycultured with tilapia (*Oreochromis niloticus*) and was highly valued for its economic and environmental benefits (Molcho et al., 2020).

The potential of polyculture systems involving whiteleg shrimp and giant freshwater prawns has also been exploited by previous studies (Cao et al., 2015; Zhang et al., 2019; Ni et al., 2021). However, research on optimal stocking densities for co-culturing whiteleg shrimp with all-male giant freshwater prawns in tank-based systems remains limited, and this is particularly essential for all-male *M. rosenbergii*, which are characterized by aggressive and cannibalistic behavior (Aziz et al., 2017). This study evaluates the growth performance, survival, and productivity of a tank-based polyculture system comprising postlarval whiteleg shrimp and all-male giant freshwater prawns at various stocking densities over two months. The findings support multi-phase grow-out strategies, which are gaining interest in the aquaculture industry. It also provides scientific information on optimal stocking densities for the practical expansion of polyculture systems involving these two species.

## Materials and Methods

**Experimental materials:** All-male giant freshwater prawns (postlarvae 15) and whiteleg shrimp (postlarvae 12) were sourced from local seed production hatcheries. Specimens were transported to the experimental aquaculture hatchery at Tra Vinh University in nylon bags, using a closed transport system (Erikson et al., 2022), with the water in the bags maintained at the production hatchery salinity (15‰). Upon arrival, prawns and shrimp were gradually acclimated to a target salinity of 5‰ by lowering the salinity by 2‰ per day. Subsequently, prawns were cultured for 2 months, reaching an average weight of 1.74 g and a length of 5.62 cm, whereas shrimp were raised for 20 days, reaching an average weight of 0.65 g and a length of 4.25 cm before being stocked for the experiment.

Two water sources were used: freshwater from a local river and saltwater (90‰) from nearby salt fields. The freshwater was settled, disinfected with

potassium permanganate (KMnO<sub>4</sub>) at 5 mg L<sup>-1</sup>, and aerated for three days. The saltwater was treated with chlorine (30 mg L<sup>-1</sup>) and aerated for four days. To prepare water at 5‰ salinity, the two sources were mixed using the dilution formula  $C_1V_1 = C_2V_2$ , where  $C_1$  = saltwater salinity,  $V_1$  = saltwater volume,  $C_2$  = target salinity, and  $V_2$  = total volume. The 4 m<sup>3</sup> composite tanks were used for experimental units, each filled with 3 m<sup>3</sup> of prepared water. A nylon mesh substrate covered approximately 20% of the tank bottom, and continuous aeration was provided throughout the trial. The commercial Grobest pellet feed containing 40% crude protein (Grobest, Vietnam) was used for the animals. This study was conducted in accordance with the guidelines of the U.S. National Research Council for the care and use of experimental animals (Directive 86/609/EEC).

**Experimental design and procedure:** This study was designed to determine the optimal stocking density for a tank-based polyculture system comprising whiteleg shrimp and all-male giant freshwater prawns, with whiteleg shrimp stocked at four densities (5, 10, 15, and 20 ind m<sup>-3</sup>) while all-male giant freshwater prawns were maintained at 5 ind m<sup>-3</sup>. The experiment followed a completely randomized design with three replications in 4 m<sup>3</sup> tanks with partial shading. It was conducted from July to September 2024 at the Aquaculture Experimental Hatchery of Tra Vinh University, southern Vietnam.

Healthy postlarval shrimp and prawns, after an adaptation and nursing period, were randomly assigned to 15 rearing tanks at designated trial densities, with three replicate tanks per density. The animals were fed to apparent satiation, with feed amounts adjusted based on the uneaten feed from the previous meal, with a feed rate of approximately 5-7% of their body weight for 60 days. Leftover feed and waste materials were removed daily at 20:00 by siphoning to maintain tank hygiene. Probiotics were also added to rearing tanks weekly at the same concentration (1 g m<sup>-3</sup>). Partial water exchanges of 20-30% were conducted every 15 days. Prior to use, water was mineral-enriched at a concentration of 10 g m<sup>-3</sup>.

**Collecting samples and calculating data:** Prior to

stocking and at 15-day intervals throughout the experimental period, five whiteleg shrimp and five giant freshwater prawns were randomly sampled from each tank to assess growth performance. Individual body wet weights were measured using an electric balance with a precision of 0.01 g after the animals were dried on absorbent paper. Total lengths were measured from the tip of the rostrum to the end of the telson using a scaled ruler (in millimeters). At the experimental end, survival rate and productivity were recorded and calculated. The formulas were used for the calculation of performance parameters as below (Hieu et al., 2022; Falahatkar et al., 2019):

Mean weight (MW, g) = total weight of 15 individuals / 15

Mean length (ML, cm) = total length of 15 individuals / 15

Daily weight gain (DWG, g day<sup>-1</sup>) = (final weight - initial weight) / number of rearing days

Daily length gain (DLG, cm day<sup>-1</sup>) = (final length - initial length) / number of rearing days

Specific growth rate in weight (SGR<sub>w</sub>, % day<sup>-1</sup>) = ((ln(final weight) - ln(initial weight)) / number of rearing days) × 100

Specific growth rate in length (SGR<sub>L</sub>, % day<sup>-1</sup>) = ((ln(final length) - ln(initial length)) / number of rearing days) × 100

Survival rate (%) = (final fish number / initial fish number) × 100

Productivity (g m<sup>-3</sup>) = biomass/rearing volume

**Water quality monitoring:** Water quality was monitored consistently throughout the experiment. Temperature and pH were measured twice daily, at 7:00 and 14:00, using a digital pH meter (Hanna HI98103, Italy). Total ammonia nitrogen (TAN), nitrite (NO<sub>2</sub><sup>-</sup>), and alkalinity were measured every 3 days at 7:00 using a Sera test kit (Germany).

**Analyzing data:** The data were analyzed using one-way ANOVA, followed by Tukey's post hoc test to identify significant differences among treatment groups at  $P \leq 0.05$ . Standard deviations were also used to evaluate data variability. All statistical analyses were conducted using SPSS (version XX; IBM Corp., Armonk, NY, USA).

Table 1. Water quality parameters during the 60-day experimental period.

	Test Time	Shrimp stocking densities (ind m <sup>-3</sup> )			
		5	10	15	20
Temperature (°C)	7:00	28.7±0.5	28.6±0.5	28.6±0.4	28.6 ± 0.4
	14:00	29.1±0.4	29.1±0.4	29.1±0.4	28.9±0.4
pH	7:00	8.0±0.1	8.0±0.1	8.0±0.1	8.0±0.1
	14:00	8.1±0.1	8.1±0.1	8.1±0.1	8.1±0.1
TAN (mg L <sup>-1</sup> )		0.14±0.0	0.18±0.0	0.19±0.0	0.25±0.0
NO <sub>2</sub> <sup>-</sup> (mg L <sup>-1</sup> )		0.45±0.0	0.60±0.2	0.82±0.1	0.94±0.0
Alkalinity (mgCaCO <sub>3</sub> L <sup>-1</sup> )		118.3±8.2	117.5±9.01	119.6±8.60	119.4±8.3

Values are presented as mean±SD.

Table 2. Initial mean weight (IMW), final mean weight (FMW), daily weight gain (DWG), and specific growth rate (SGR<sub>w</sub>) of all-male giant freshwater prawns and whiteleg shrimp postlarvae for 60-day polyculture at different stocking densities.

Shrimp stocking densities (ind m <sup>-3</sup> )	IMW (g ind <sup>-1</sup> )	FMW (g ind <sup>-1</sup> )	DWG (g day <sup>-1</sup> )	SGR <sub>w</sub> (% day <sup>-1</sup> )
<i>M. rosenbergii</i>				
5	1.74±0.30 <sup>a</sup>	14.50±3.09 <sup>b</sup>	0.21±0.05 <sup>b</sup>	3.50±0.32 <sup>b</sup>
10	1.74±0.30 <sup>a</sup>	14.15±2.93 <sup>b</sup>	0.21±0.05 <sup>b</sup>	3.46±0.33 <sup>b</sup>
15	1.74±0.30 <sup>a</sup>	10.88±1.76 <sup>a</sup>	0.15±0.03 <sup>a</sup>	3.03±0.26 <sup>a</sup>
20	1.74±0.30 <sup>a</sup>	9.92 ± 1.13 <sup>a</sup>	0.14 ± 0.02 <sup>a</sup>	2.89±0.19 <sup>a</sup>
<i>L. vannamei</i>				
5	0.65±0.14 <sup>a</sup>	13.61±1.52 <sup>c</sup>	0.22 ± 0.03 <sup>c</sup>	5.06±0.18 <sup>c</sup>
10	0.65±0.14 <sup>a</sup>	12.81±1.17 <sup>c</sup>	0.21±0.02 <sup>b</sup>	4.96±0.16 <sup>b</sup>
15	0.65±0.14 <sup>a</sup>	10.95±1.37 <sup>b</sup>	0.17±0.02 <sup>a</sup>	4.69±0.20 <sup>a</sup>
20	0.65 ± 0.14 <sup>a</sup>	10.6±1.47 <sup>a</sup>	0.17±0.02 <sup>a</sup>	4.64±0.23 <sup>a</sup>

Values are presented as mean±SD. Values with different letters (a, b, c) in the same row show a significant difference ( $P \leq 0.05$ ).

Table 3. Initial mean length (IML), final mean length (FML), daily length gain (DLG), and specific growth rate in length (SGR<sub>L</sub>) of all-male giant freshwater prawns and whiteleg shrimp postlarvae for 60-day polyculture at different stocking densities.

Shrimp stocking densities (ind m <sup>-3</sup> )	IML (cm ind <sup>-1</sup> )	FML (cm ind <sup>-1</sup> )	DLG (cm day <sup>-1</sup> )	SGR <sub>L</sub> (% day <sup>-1</sup> )
<i>M. rosenbergii</i>				
5	5.62±0.46 <sup>a</sup>	11.17±0.76 <sup>bc</sup>	0.09±0.01 <sup>bc</sup>	1.14±0.11 <sup>bc</sup>
10	5.62±0.46 <sup>a</sup>	11.50±0.85 <sup>c</sup>	0.10±0.01 <sup>c</sup>	1.19±0.12 <sup>c</sup>
15	5.62±0.46 <sup>a</sup>	10.82±0.73 <sup>b</sup>	0.09±0.01 <sup>b</sup>	1.09±0.11 <sup>b</sup>
20	5.62±0.46 <sup>a</sup>	10.39±0.56 <sup>a</sup>	0.08±0.01 <sup>a</sup>	1.02±0.09 <sup>a</sup>
<i>L. vannamei</i>				
5	4.25±0.20 <sup>a</sup>	12.08±0.88 <sup>b</sup>	0.13±0.01 <sup>b</sup>	1.74±0.12 <sup>c</sup>
10	4.25±0.20 <sup>a</sup>	12.10±0.82 <sup>b</sup>	0.13±0.01 <sup>b</sup>	1.74±0.12 <sup>c</sup>
15	4.25±0.20 <sup>a</sup>	11.12±0.94 <sup>a</sup>	0.11±0.02 <sup>a</sup>	1.60±0.14 <sup>b</sup>
20	4.25±0.20 <sup>a</sup>	10.69±0.82 <sup>a</sup>	0.10±0.01 <sup>a</sup>	1.53±0.12 <sup>a</sup>

Values are presented as mean±SD. Values with different letters (a, b, c) in the same row show a significant difference ( $P \leq 0.05$ ).

## Results

**Water quality parameters:** Throughout the experiment, water quality conditions remained consistent. Recorded temperature values ranged from 28.6 to 29.1°C, while pH levels remained between 8.0 and 8.1. TAN was maintained within the range of 0.14 to 0.18 mg L<sup>-1</sup>, NO<sub>2</sub><sup>-</sup> levels ranged from 0.45 to 0.94 mg L<sup>-1</sup>, and alkalinity remained stable between 117 and 119 mg CaCO<sub>3</sub> L<sup>-1</sup> ( $P \geq 0.05$ ) (Table 1).

**Rearing performance:** Both all-male giant freshwater and white-leg shrimp showed better growth performance at lower stocking densities (5 and 10 ind

m<sup>-3</sup>) than at higher densities (15 and 20 ind m<sup>-3</sup>). Specifically, in all-male giant freshwater, all growth parameters (FMW, DWG, SGR<sub>w</sub>, FML, DLG, and SGR<sub>L</sub>) were not significantly different between 5 and 10 ind m<sup>-3</sup> densities ( $P \geq 0.05$ ; Table 2), but these parameters in both were significantly greater compared to those at 15 and 20 ind m<sup>-3</sup> ( $P \leq 0.05$ ; Table 2). White-leg shrimp showed a similar pattern (Table 2).

The highest survival rates were observed at shrimp stocking densities of 5 and 10 ind m<sup>-3</sup>, which did not differ significantly from each other ( $P \geq 0.05$ ; Fig. 1).

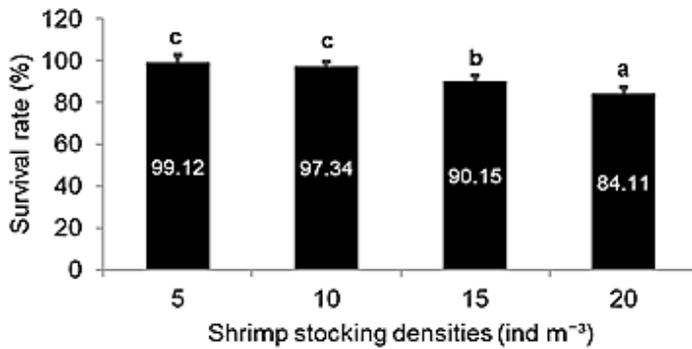


Figure 1. Survival rates after a 60-day polyculture of all-male giant freshwater prawns and whiteleg shrimp postlarvae at different shrimp stocking densities. The bars with different letters (a, b, and c) show a significant difference ( $P \leq 0.05$ ).

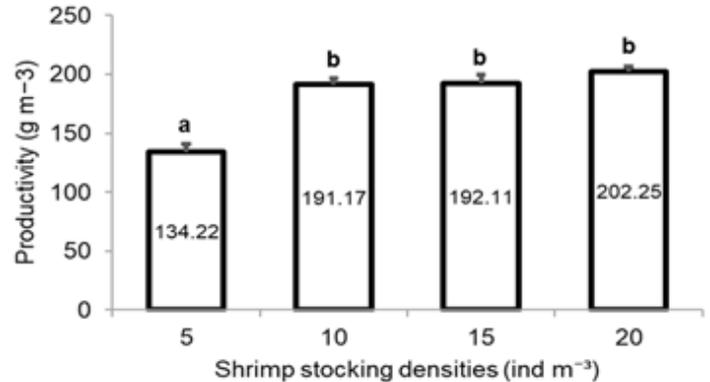


Figure 2. Productivity after a 60-day polyculture of all-male giant freshwater prawns and whiteleg shrimp postlarvae at different shrimp stocking densities. The bars with different letters (a, b) show a significant difference ( $P \leq 0.05$ ).

However, at stocking densities of  $\geq 15$  ind m<sup>-3</sup>, survival rates significantly decreased as density increased ( $P \leq 0.05$ ; Fig. 1).

Productivity was significantly lower at a stocking density of 5 ind m<sup>-3</sup> compared to higher densities ( $P \leq 0.05$ ; Fig. 2). No significant differences in productivity were observed among densities 10, 15, and 20 ind m<sup>-3</sup> ( $P \geq 0.05$ ; Fig. 2). This suggests that increasing stocking density up to 10 ind m<sup>-3</sup> significantly enhances productivity, but further increases beyond this point do not result in statistically significant gains.

## Discussions

**Water quality parameters:** Water quality parameters mainly remained stable throughout the experiment. The temperature stayed between 28.6 and 29.1°C, and the pH ranged from 8.0 to 8.1. Total ammonia nitrogen (TAN) was between 0.14 and 0.18 mg L<sup>-1</sup>, while nitrite (NO<sub>2</sub><sup>-</sup>) levels were from 0.45 to 0.94 mg L<sup>-1</sup>. Alkalinity remained between 117 and 119 mg CaCO<sub>3</sub> L<sup>-1</sup>. These conditions are considered suitable for the growth and survival of *L. vannamei* and *M. rosenbergii* (Boyd, 1998; Ni et al., 2021; Silveira et al., 2022; Yusoff et al., 2024).

**Rearing performance:** Aquaculture professionals increasingly view polyculture systems as sustainable alternatives to monoculture, as they offer better resource use and ecological balance. However, excessive shrimp densities can reduce growth and survival due to organic loading and competition

(Martínez-Porchas et al., 2010; Liu et al., 2017; Jewel et al., 2021). Furthermore, *M. rosenbergii*, a benthic and territorial species, exhibits heightened sensitivity to crowding (Negrini et al., 2017; Dong et al., 2018). This sensitivity is particularly pronounced in all-male populations, which are highly aggressive and space-demanding; high stocking densities often lead to elevated stress levels and increased intraspecific conflict (Aziz et al., 2017). In contrast, *L. vannamei* (whiteleg shrimp) are non-aggressive, schooling, pelagic shrimp that display strong adaptability to varying salinities and feeding regimes. Although they can tolerate moderate to high stocking densities and generally thrive under such conditions, they remain vulnerable to competition for resources and to the adverse effects of deteriorating water quality (Costa et al., 2016; Hague et al., 2025). Prasetyo et al. (2014) reported that *L. vannamei* postlarvae achieved a high growth performance and a 90% survival rate at a salinity of 5‰. Their complementary behavior and habitat may make all-male giant freshwater prawns and white-leg shrimp a promising polyculture strategy. Based on these ecological and behavioral traits, this study maintained a fixed density of all-male prawns at 5 ind m<sup>-3</sup> and tested four shrimp densities (5, 10, 15, and 20 ind m<sup>-3</sup>) to assess density-dependent effects on their growth, survival, and productivity at 5‰ salinity.

The results of the present study demonstrated that increasing the stocking density of *L. vannamei* beyond

10 ind m<sup>-3</sup> negatively affected the growth performance and survival rates of both cultured species. This finding aligns with previous research showing that overcrowding in aquaculture systems increases competition for feed, space, and social interaction (Diao et al., 2024). The negative effects of increased stocking density are particularly evident in *M. rosenbergii*, a species known for its territorial and aggressive behavior, which is especially pronounced in all-male populations (Aziz et al., 2017; Hooper et al., 2022; Chakraborty, 2024). In *M. rosenbergii*, aggressive encounters in high-density environments can lead to physical injuries, which often result in secondary infections (Metcalf et al., 1989; Ibrahim et al., 2025). While *L. vannamei* is less aggressive, it is susceptible to declining water quality, especially low dissolved oxygen and elevated ammonia, conditions that worsen with increased density (Cao et al., 2015; Ni et al., 2021). Although the water quality parameters presented in Table 1 do not show significant differences among treatments and are within the appropriate ranges, TAN and nitrite (NO<sub>2</sub><sup>-</sup>) levels tended to rise at higher shrimp densities. It is well-known that high stocking densities deteriorate water quality by increasing metabolic waste products such as ammonia and carbon dioxide, consuming more dissolved oxygen, and leading to higher concentrations of nitrates and other harmful compounds (Sundh et al., 2019).

Moreover, previous studies have demonstrated that high stocking density can induce chronic stress, resulting in adverse physiological and biochemical changes. It can damage cells, disrupt intracellular homeostasis, induce oxidative stress, suppress the immune system, increase disease susceptibility, and ultimately reduce survival in many crustacean and fish species. Such effects have been reported in *L. vannamei* (Liu et al., 2017), fingerling *Oreochromis niloticus* (Liu et al., 2018), fry *Ompok bimaculatus* in biofloc systems (Majhi et al., 2023), juvenile *Acipenser sinensis* in recirculating systems (Long et al., 2019), and *Aulonocara* sp. in plastic tanks (Mahalakshmi et al., 2024). In addition, crowding stress increases the energy demands associated with

physiological coping mechanisms, thereby reducing the energy available for growth (Yang et al., 2020; Jia et al., 2022). Although growth and survival declined at higher shrimp stocking densities, productivity increased from 5 to 10 ind m<sup>-3</sup> before plateauing at higher levels. This pattern reflects a common trade-off in aquaculture. While increasing density can improve overall yield, benefits beyond a biological threshold are diminished by stress, reduced feed efficiency, disease, and mortality (Shoko et al., 2016; Oké and Goosen, 2019). Similar trends have been reported in biofloc systems, where moderate stocking density increases enhanced production, whereas excessive stocking negatively affects performance (Silveira et al., 2022). Furthermore, no significant differences in growth performance or survival rate were observed between the 5 and 10 ind m<sup>-3</sup> stocking densities of whiteleg shrimp. However, significantly lower productivity was recorded at 5 ind m<sup>-3</sup>, likely due to the smaller initial stocking quantity, which limited the total biomass yield. This suggests suboptimal utilization of tank capacity at the lower stocking density.

While populations of *L. vannamei* and *M. rosenbergii* were evaluated as compatible for co-farming (Zhang et al., 2019; Ni et al., 2021), this study has indicated that the polyculture performance of all-male giant freshwater prawns and whiteleg shrimp is highly dependent on appropriate density management. Overall, a shrimp stocking density of 10 ind m<sup>-3</sup> combined with 5 ind m<sup>-3</sup> of all-male giant freshwater prawns provides the best balance between growth, survival, and system productivity in tank-based polyculture. Similarly, Ni et al. (2021) evaluated the polyculture performance of *L. vannamei* and *M. rosenbergii* in intertidal mudflat ponds near Hangzhou Bay, China, and found that system performance was also influenced by stocking density. In intertidal mudflat pond-based polyculture systems, the authors recommended an optimal stocking density of 900,000 shrimp ha<sup>-1</sup>, co-cultured with 150,000 prawns ha<sup>-1</sup>.

## Conclusions

This study identified the optimal stocking density for tank-based polyculture of whiteleg shrimp (*L. vannamei*) and all-male giant freshwater prawn (*M. rosenbergii*) as 10 shrimp m<sup>-3</sup> and 5 prawns m<sup>-3</sup>, respectively. This density combination provided the best overall balance among growth performance, survival rate, and productivity. It outperformed higher stocking densities (15-20 shrimp m<sup>-3</sup>) in terms of survival and growth, while achieving greater productivity than the lowest density (5 shrimp m<sup>-3</sup>). These findings offer practical insights into density-dependent management strategies for co-cultures of these animals in intensive tank-based systems. Further research on feeding regimes and feed efficiency is recommended to support feed management strategies and to enhance the performance of polyculture systems for these animal populations.

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